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Patent Abstract

EPB 02-26 0785298 **Rapid cooling of cz silicon crystal growth system**

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PATENT ASSIGNEE(S)- MEMC Electronic Materials, Inc. (1124321) 501 Pearl Drive, P.O. Box 8 St. Peters, Missouri 63376 US **DESG. COUNTRIES**- DE; FR; GB; IT
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EXEMPLARY CLAIMS- A Czochralski method for producing monocrystals, the method comprising: pulling a single crystal silicon rod (13) from a silicon melt (9) contained in a crucible (3) within a growth chamber; and cooling the growth chamber by flowing a cooling gas consisting of at least about 50% helium by volume and having a thermal conductivity of at least about 55x10sup-5 g.cal./(sec. cmsup2)(.C/cm) at 800.K into the growth chamber after the single crystal silicon rod (13) is pulled from the silicon melt (9). A method according to claim 1, wherein the cooling gas has a thermal conductivity of between about 62x10sup-5 and 80x10sup-5 g.cal./(sec.cmsup2) (.C/cm) at 800.K and consists of at least about 70 % helium by volume. A method according to claim

1 or claim 2, wherein the cooling gas consists of at least about 90% helium by volume. A method according to any one of claims 1 to 3, the method comprising: pulling the single crystal silicon rod (13) from the silicon melt (9) under a continuous flow of argon; and cooling the growth chamber interior to a temperature of less than about 250.C by flowing the cooling gas into the growth chamber after the single crystal silicon rod (13) is pulled from the silicon melt (9). A method according to claim 1, wherein the method is conducted in a crystal pulling apparatus comprising the growth chamber, a pulling chamber above the growth chamber, a heating apparatus (5) within the growth chamber for heating the crucible (3), insulation (25) in the growth chamber and disposed generally circumferentially about the heating apparatus (5) for resisting heat losses from the crucible (3), and a cooling apparatus (33) disposed generally circumferentially about the insulation (25) for cooling the crucible, the method comprising: evacuating the growth chamber after the crystal (13) has been pulled; energizing the cooling apparatus (33); introducing the cooling gas into the growth chamber; and holding the cooling gas in the growth chamber to increase the cooling effectiveness of the cooling apparatus (33). A method according to claim 5, wherein the cooling gas consists of at least about 70% helium by volume. A method according to claim 1, the method comprising: pulling the single crystal silicon rod (13) from the silicon melt (9) under a continuous flow of inert gas while maintaining the crucible (3) and the growth chamber interior at a temperature greater than about 500.C and at a pressure of less than about 1 torr (about 133 Pa) by application of a vacuum to the growth chamber; discontinuing the application of vacuum to the growth chamber while the crucible and growth chamber interior are at a temperature of at least about 500.C; flowing the cooling gas into the growth chamber and thereby increasing the pressure within the growth chamber to at least about 50 torr (about 6666 Pa); and cooling the growth chamber by maintaining the pressure within the growth chamber at at least about 50 torr (about 6666 Pa) until the temperature of the growth chamber interior and crucible are below about 250.C. A method according to claim 1, the method comprising: pulling the single crystal silicon rod (13) from a silicon melt (9) contained in a crucible (3) within a growth chamber having inner walls lined with insulation (25) while maintaining the temperature of the crucible (13) and the growth chamber interior at a temperature of at least about 500.C; and cooling the crucible (3) and growth chamber interior to a temperature below about 250.C after the crystal (13) is pulled by flowing the cooling gas into the growth chamber and infiltrating pores of the insulation (25) with the cooling gas to increase the insulation's thermal conductivity, thereby causing heat to be pulled away from the crucible (3) and growth chamber interior. A method according to claim 1, the method comprising: pulling the single crystal silicon rod (13) from a silicon melt (9) contained in a crucible (3) within a growth chamber having insulation (25) on its inner walls while purging the growth chamber with a continuous flow of an inert gas at a flowrate of between about 20 and about 150 liters per minute and maintaining the growth chamber interior at a temperature greater than about 500.C and at a pressure of less than about 1 torr (about 133 Pa) by application of a vacuum to the growth chamber; discontinuing the application of vacuum to the growth chamber while the crucible (3) and growth chamber interior are at a temperature of at least about 500.C; flowing the cooling gas, which consists of at least 70%

helium by volume, into the growth chamber to increase the pressure within the growth chamber to at least about 50 torr (about 6666 Pa) and to infiltrate pores of the insulation (25) with the cooling gas, thereby increasing the thermal conductivity of the insulation (25) and the rate at which the insulation (25) causes heat to be pulled away from the crucible (3) and growth chamber interior; and cooling the crucible (3) and growth chamber interior to a temperature below about 250.C by maintaining the pressure within the growth chamber at at least about 50 torr (about 6666 Pa) until the temperature of the growth chamber interior and crucible (3) are below about 250.C.

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A Czochralski method for producing monocrystals wherein a single crystal silicon rod (13) is pulled from a silicon melt (9) contained in a crucible (3) within a chamber (1). After pulling the single crystal silicon rod (13) from a silicon melt (9) in a chamber (1), the chamber (1) is cooled by flowing a gas having a thermal conductivity of at least about 55x10sup-5 g.cal./(sec.(dark circle) cmsup2) (.C/cm) at 800.K into the chamber (1). The preferred cooling gas is a helium-containing gas.

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